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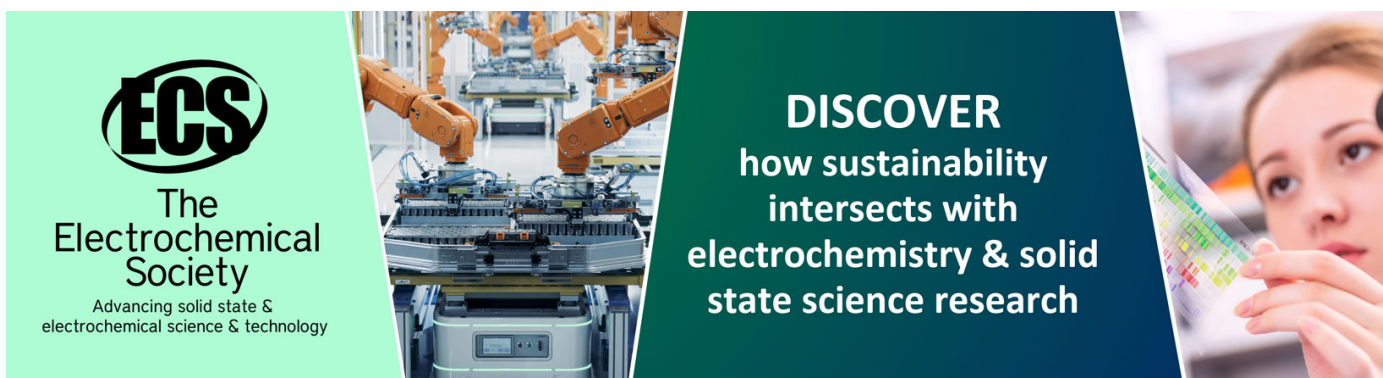
Research on power resource based on time series analysis

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Research on power resource based on time series analysis

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Abstract. In recent years, electronic devices have been found everywhere in our lives, and many public places now offer free charging devices that are convenient for people to use. This paper studies the changing rules and future development trends of free charging demand and cost in public places, and gives a concrete model for calculating the cost and demand function of power resources in various occasions. For the first problem, we first found the use of power resources in the past ten years, and then described the trend of the free charging power demand in public places through a visual method. Then we introduce a time series model to predict the future demand of power resources, and use the data from 2000 to 2018 to predict the trend of power demand in 2019-2025. It can be seen that electricity consumption will continue to increase in the next few years, and the trend is more obvious than before. For question two, we first considered the cost of free charging in public. Since the free charging in public areas is somewhat similar to shared charging devices, we used the first question model to predict the cost of sharing charging devices in the coming week. Demand trends, by introducing parameters such as average device charging power, number of devices, and number of outlets, we established a power cost model and discussed the scope and scope of these costs. For the third problem, we revised the second question based on the parameters of different types of public places such as shopping centers, cafes, schools, etc., and constructed different cost models for calculation, and analyzed the models for different public places. The scope and strategy of the parameters. In response to question four, we have proposed measures to reduce the cost of energy use in public places from the perspective of the government and the public. It also analyzes the characteristics of free charging in schools and shopping malls, and finds measures to reduce energy consumption in public places in both cases. In response to question five, we wrote an article for the school newspaper about the electricity consumption in China in recent years and the measures to reduce the cost of electricity, and called on everyone to save electricity.

Keywords: Time series analysis; Cost-benefit function; Forecast; Matlab.

1. Introduction

In recent years, electronic devices have been found everywhere in our lives, and many public places now offer free charging devices that are convenient for people to use. This paper studies the changing rules and future development trends of free charging demand and cost in public places, and gives a concrete model for calculating the cost and demand function of power resources in various occasions.



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For question 1, discuss how has this type of energy consumption has changed over recent years and how it will continue to change. Identify impacts on, and requirements of, public places with these increasing energy (electricity) and charging demands.

For question 2, use your identified impacts and requirements to develop a model for the resulting costs of the increased demands and energy usage on public places. Discuss the extent of these costs and how they are paid. Requires the establishment of a model to solve the problem of energy cost caused by free charging in public areas. The cost is related to the electricity cost per kilowatt-hour, the average charging power of devices on the socket, the number of devices and the number of sockets. Therefore, in this part, we need to find the relationship between these four factors and the cost, so as to establish the cost model.

For question 3, we refine the model in problem two in the case of different types of public places. We select schools, cafes and shopping malls for research and constructed three cost models based on question 2 respectively.

In question 4, we analyze the characteristics of free charging in schools and shopping malls respectively, and find the cost measures to reduce energy consumption in public places in these two situations.

Question 5 is to write a one-page article for your school newspaper describing your findings and recommendations.

2. Assumptions

Throughout this paper, we do the following general assumptions.

- Electric wires and other equipment do not cause the loss of electric energy, that is, we only consider the electric energy cost generated by charging electronic devices.
- The proportion of electric energy consumed by people to charge their electronic devices in public places remains the same.
- Each charging socket can only charge one device at the same time
- If someone is charging in a certain period of time, it will be charged all the time.
- People in the shopping center charge not only their phones, but also their phones and computers.

3. Symbol Description

The following lists the major symbols that are used in this paper.

Table 1. The following lists the major symbols that are used in this paper.

<i>Symbol</i>	<i>Meaning</i>
H_i	the electricity consumption of i years
P	the hysteresis operator
c	the autoregressive part parameter
θ	the moving average part parameter
m	the error term
d	the number of differences made
n	power consumption
a	loss of electric energy

P.s: Other symbols' instructions will be given in the text.

4. Task 1: Time Series Prediction Model

4.1. Model Preparation: Data Preprocess

According to the meaning of the question, we found the power consumption of China in the past ten years. Through observation and analysis, we processed the data obtained in the following steps.

Table 2. Chinese energy consumption in the past decade

Year	Electrical energy consumption
2000	13254
2001	14687
2002	17862
2003	19285
2004	21054
2005	25432
2006	26333
2007	27348
2008	29364
2009	35247
2010	36888
2011	39200
2012	42314
2013	44356
2014	47568
2015	49245
2016	54365
2017	58341
2018	69332

4.2. Draw an intuitive form

From the data given on the Internet, develop a two-dimensional table of the year and annual electricity consumption (see Table 2) and observe the changes in annual consumption:

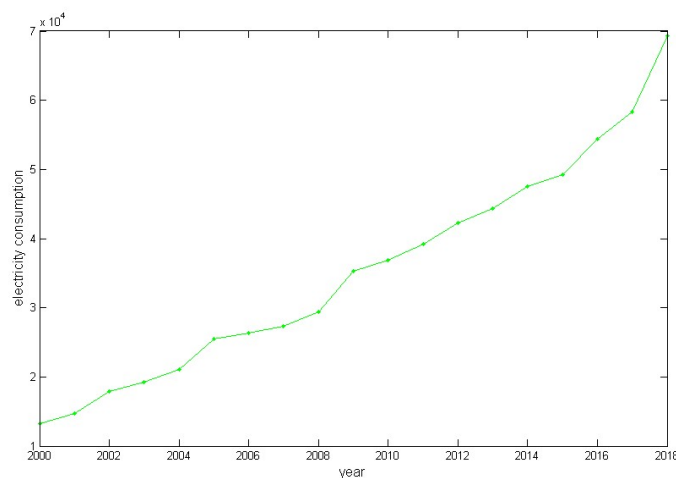


Figure 1. Line change chart of annual electricity consumption

To build this question's model, we needed a mass of data and we chose Waliguan to do some analyses. Firstly, we wondered if we need to take season into account. So we made three scatter diagrams, respectively about 2003, 2009 and 2012, describing ozone concentration's daily change in Waliguan.

4.3. Model establishment and solution

4.3.1. The establishment of the model. Time series (or dynamic series) refers to the same statistical indicators of the value of the time they occurred in the order of the sequence. The main purpose of time series analysis is to predict the future based on available historical data.

Its contents include:

- ① Collecting and sorting out the historical data of a phenomenon
- ② These materials are checked and identified and arranged in a series
- ③ Analysis of time series, from which to find the phenomenon of change with time and the law, come to a certain pattern
- ④ This model is used to predict the future of the phenomenon

To build this question's model, we needed a mass of data and we chose Waliguan to do some analyses. Firstly, we wondered if we need to take season into account. So we made three scatter diagrams, respectively about 2003, 2009 and 2012, describing ozone concentration's daily change in Waliguan. The diagrams are shown as below.

Apparently, the concentration changed smoothly without obvious fluctuations. Considering the Montreal Protocol and all the efforts people have made, we can accept the result's validity. Therefore, we regarded this change as a stationary process. There were three models that can describe the stationary process: AR, MA, and ARMA. ARMA (Autoregressive–moving-average) consisted of two parts, an autoregressive (AR) part and a moving average (MA) part [4]. We can see their functions from their names. And they are written as below:

Given a time series of data, the ARMA model is a tool for understanding or predicting future data in the time series. The model consists of two parts: an autoregressive (AR) part and a moving average (MA) part. The AR part takes its past value as a regression variable; the MA part involves modeling the error term as a linear combination of the error terms that occur now and in the past at different times. This model is commonly referred to as the ARMA(p, q) model, where p is the order of the autoregressive parts and q is the order of the moving average parts. The expression AR(p) refers to the p-order autoregressive model:

$$Y_t = c + \sum_{i=1}^p \alpha_i \varepsilon_{t-i} + \varepsilon_t$$

Where p is the parameter, c is a constant, the random variable ε is the error term, and α_i is the correlation coefficient.

The expression MA(q) refers to the moving average model of the q-order:

$$Y_t = \mu + \sum_{i=1}^q \theta_i \varepsilon_{t-i} + \varepsilon_t$$

Where q is the parameter, μ is the expectation of Y_t , the random variable ε is the error term, and θ_i is the correlation coefficient.

The expression ARMA(p, q) is an autoregressive moving average model:

$$Y_t = \sum_{i=1}^p \alpha_i Y_{t-i} + \sum_{i=1}^q \theta_i \varepsilon_{t-i} + \varepsilon_t + c$$

The ARIMA model, the autoregressive integral moving average model. It is a model constructed by transforming an unstable time series into a stable time series model and then subjecting the dependent variable to the regression of the present value and the lag value of the random error term. In the case of

identification, this model can predict future values from historical and current values of the time series. Given a set of sequences at a given time, the ARIMA model can be given by the following formula:

$$(1 - \sum_{i=1}^p \alpha_i)(1 - L)^d X_t = \delta + (1 + \sum_{i=1}^q \theta_i L^i) \varepsilon_t$$

L is the hysteresis operator, α is the autoregressive part parameter, θ is the moving average part parameter, ε is the error term, and d is the number of differences made when the time series becomes stationary. We can estimate the ARIMA model according to the Box – Jenkins method.

The second exponential smoothing method is suitable for short-term predictions in which the time series exhibits linear growth.

Solve this model with MATLAB and its prediction results are shown below:

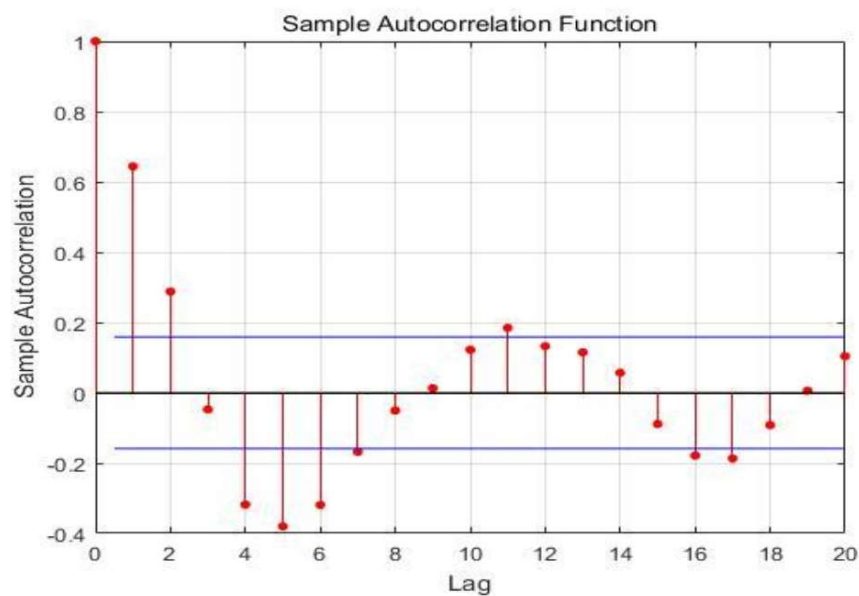


Figure 2. Stationary Process's Partial Autocorrelation Function.

In these two pictures, we can see four blue lines which represent confidence intervals. The values of p and q were confirmed by the red dots who are in the confidence intervals. Therefore, we knew that p 's data range was $[0,11]$ and q 's data range was $[0,7]$. In addition, p and q were both tailing factors, so we chose ARMA to describe our stationary process.

Then, the most significant task was that we needed p and q 's exactly value. The Akaike information criterion (AIC) is a measure of the relative quality of statistical models for a given set of data. We used matlab to do a quantity of count among AIC and here are our results:

Table 3. P and q's value

$\begin{smallmatrix} p \\ q \end{smallmatrix}$	0	1	2	3	4	5	6	7
0	5.24671	5.19302	5.21955	5.08419	5.06378	4.99801	5.00640	4.91609
1	5.25456	5.20461	5.05184	5.06339	5.04287	5.06351	4.99750	4.88822
2	5.24186	4.74882	5.22517	5.21161	5.19890	5.13562	5.00857	5.03129
3	4.84328	4.71696	4.51961	4.66835	4.54368	4.75115	4.57312	4.98629
4	4.75699	4.72386	4.77776	4.74026	4.65510	4.49376	4.48867	4.53587
5	4.74782	4.74674	4.75049	4.76218	4.53528	4.66004	4.61853	4.49093
6	4.75971	4.79770	4.75957	4.76577	4.54088	4.56932	4.75498	4.60906
7	4.79305	4.80563	4.68911	4.72238	4.63646	4.49647	4.48330	4.57683
8	4.77175	4.78367	4.73756	4.74278	4.56533	4.69770	4.76160	4.56549
9	4.82983	4.79987	4.78795	4.62560	4.63029	4.66039	4.55966	4.52249
10	4.81285	4.82080	4.79780	4.59590	4.61863	4.62021	4.60465	4.51753
11	4.81453	4.80057	4.81643	4.61610	4.63030	4.60741	4.59102	4.53445

The yellow one means the minimum of the numbers. Therefore, we know that:

$$p = 6, q = 7$$

And the predicting function is that:

$$X_t = 0.8578X_{t-1} + 0.416X_{t-2} + \dots + \varepsilon_t - 0.2967\varepsilon_{t-1}$$

4.3.2. Solution and Result. Parameters change as long as the change of time. It means in the prediction process, we always need to adjust the value of parameters to predict next month's ozone level. Solve this model with MATLAB and its prediction results are shown below:

Table 4. Time Model's Checkout

Year	True value	Predicted value	Measurement error
2010	36888	37004	2.11%
2011	39200	39248	2.61%
2012	42314	42412	1.53%
2013	44356	45014	2.56%
2014	47568	47623	0.58%
2015	49245	49388	1.12%
2016	54365	55434	2.22%
2017	58341	59271	1.58%
2018	69332	69433	0.48%

We can see from the table that our time model is reliable. But apparently, if we want to predict the ozone level in any time and any place, we also need to build an area model.

In recent years, power consumption has risen remarkably. In 2018, China's total electricity consumption reached 68.49 billion kWh, an increase of 8.5% year-on-year, and 6.85 trillion kWh was 6.85 trillion kWh. According to the calculation of 1.4 billion people, that electricity consumption per capital. The amount is 4,889 kWh, and the monthly average is 407.4 kWh, which is a surprising amount of data. Our time series prediction model predicts that power consumption will continue to increase over

the next few years, and the acceleration of its growth will increase slightly. The identification of energy (electricity) and increased demand for electricity continues to increase the demand for electricity in public places. As people spend more and more time on various electronic devices, the demand for charging facilities in public places is increasing, making public places The power load increases with the day.

The results of the demand for power resources are predicted in the next five years as shown in the following table: Forecasting results for the next 5 years.

Table 5. Forecasting results for the next 5 years

Year	Predicted value
2019	72108
2020	73185
2021	75124
2022	79305
2023	84569
2024	87234
2025	92134

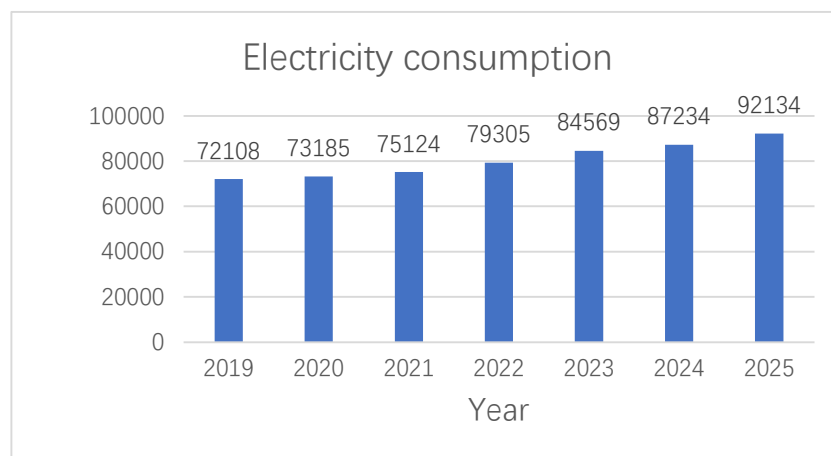


Figure 3. Forecasting results for the next 5 years

5. Task 2: Cost requirement model

5.1. Model preparation

The topic asks us to use the impact and needs identified in the first question to build a model for the increased demand in public places and the cost of energy use. Discuss the scope and payment methods of these fees.

We only consider the energy costs of free charging in public areas, so we don't have to consider other costs, such as equipment costs, maintenance costs and other unrelated costs. Due to the similarity between free charges in public areas and sharing charges.

We can macroscopically quantify the cost of power resources by dealing with the cost of sharing charging treasures.

The question only asks us to analyze the energy cost of free charging in public areas, so we do not need to consider other equipment costs, maintenance costs and other unrelated expenses. Due to the similarity between free charging in public areas and shared charging data, we can work on the macro data of shared charging treasure. But you need to pay attention to the essential difference: shared charging treasure is a fee-based service, no charge for free charging. This may greatly increase the

enthusiasm of people using free charging outlets. The energy cost of free charging in public areas is all from the consumption of electricity, and the electricity bill per kilowatt hour (c) is different at different times, so we can roughly divide the cost into hours. In the public area, the hourly traffic (V) affects the number of people charging. Since the passenger flow per unit time approximates the Poisson distribution, we can roughly estimate the parameters of the Poisson distribution based on the data available at different times and locations. Also, note that not everyone will use free charging, we additionally assume the percentage constant “Use charging ratio” (r), which indicates the ratio of the current customer who wants to use the power supply to the current passenger flow. r If there are too many people who want to charge, it is obvious that the device that is being charged at the same time cannot exceed the upper limit of the number of outlets (N). Due to the different power of charging devices, such as mobile phones and computers, in order to simplify the model, we consider the average charging power (P) according to different places (for example, more people may charge the computer in the coffee shop, but more people in the shopping mall may charge the mobile phone. Therefore, the average power of the equipment in the coffee shop is higher than that in the shopping mall. To simplify the model, assume that each charging outlet can only charge one device at the same time, and if the guest charges within an hour, it is assumed to be charging for that hour. For more accurate estimates, the statistical interval can be shortened, for example by changing one hour to half an hour or fifteen minutes.

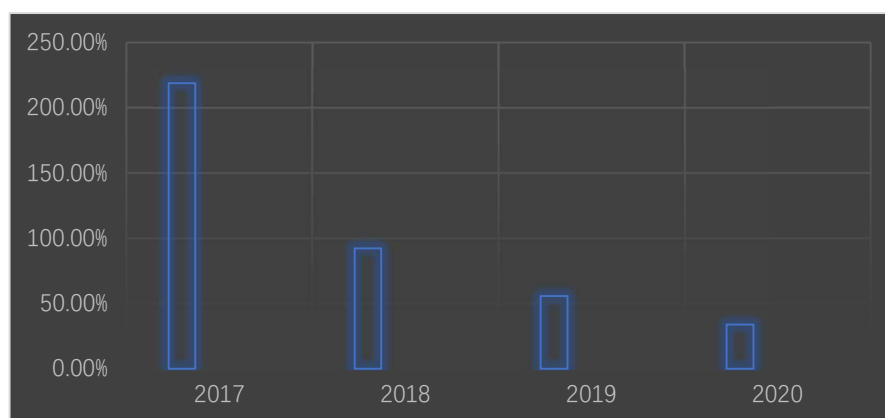


Figure 4. 2017-2020 China shared charging treasure user scale growth rate and forecast

5.2. Model establishment and solution

5.2.1. The establishment of the model. (1) Let the decision matrix of this problem be F , and the normalized decision matrix Z' can be formed, whose element is Z'_{ij} .

$$Z'_{ij} = \frac{f_{ij}}{\sqrt{\sum_{i=1}^n f_{ij}^2}}, i = 1, 2, \dots, 5, j = 1, 2, \dots, 6;$$

At present, the charging standard for shared charging treasure is 2 yuan / hour, so this paper investigates the use of a shared charging treasure in a shopping mall, and analyzes the usage time of the shared charging treasure in the shopping mall, namely:

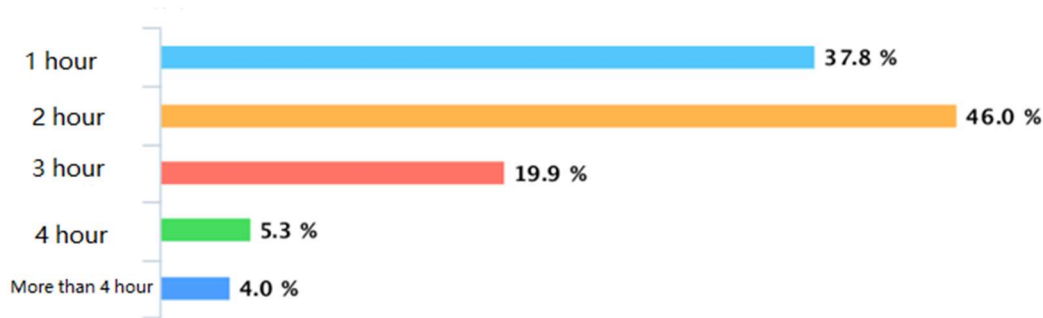


Figure 5. Statistical data

Calculate to get:

$$f_{\max} = 0.10 \times 0.213 + 0.15 \times 0.286 + 0.20 \times 0.417 + 0.25 \times 0.084 = 0.4 \text{ yuan/15min}$$

According to the identified indicators, it can be compared before and after the occurrence of human damage, loss, etc., because the weights of the indicators have different effects on the company's benefits and management. Therefore, this paper uses the fuzzy comprehensive evaluation method for analysis. Firstly, the fuzzy evaluation matrix R is obtained by the fuzzy comprehensive evaluation method, and then the weight vector A is obtained by using the large Cauchy distribution function. Finally, the fuzzy evaluation vector B is obtained by the fuzzy multiplication $B = A \odot R$ of the matrix, and the B is obtained. After normalization, the conclusion is drawn according to the principle of maximum membership.

The comprehensive four indicators are available:

u_1 = "cost", u_2 = "benefit", u_3 = "Management difficulty", u_4 = "Consumer satisfaction"; then $U = \{u_1, u_2, u_3, u_4\}$ is factor set

Comment set $V = \{v_1, v_2, v_3, v_4\}$, among them v_1 = "perfect", v_2 = "well", v_3 = "general",

v_4 = "bad", corresponding value 5, 4, 3, 2. According to the company's benefits and management related data can be obtained separately u_1, u_2, u_3, u_4 univariate evaluation vector R_1, R_2, R_3, R_4 , They form a judging matrix (which indicates the degree to which the program is at the jth level of the i-th goal).

Take a large Cauchy distribution function (see below) as a membership function of the evaluation

$$f(x) = \begin{cases} [1 + a(x-b)^{-2}]^{-1}, & 1 \leq x \leq 3 \\ c \ln x + d, & 3 \leq x \leq 5 \end{cases}$$

According to this, the values of a, b, c, and d are obtained, and the weight vector A is obtained by taking the above equation.

5.2.2. The solution of the model. Assess the impact of the impact on the delivery plan

According to surveys and calculations:

Judging matrix without considering human damage, loss, etc. $R = \begin{pmatrix} 0.4 & 0.2 & 0.3 & 0.1 \\ 0.4 & 0.3 & 0.1 & 0.2 \\ 0.5 & 0.2 & 0.2 & 0.1 \\ 0.6 & 0.1 & 0.2 & 0.1 \end{pmatrix};$

Judgment matrix when considering human damage, loss, etc. $R = \begin{pmatrix} 0.3 & 0.2 & 0.3 & 0.2 \\ 0.2 & 0.3 & 0.4 & 0.1 \\ 0.2 & 0.2 & 0.4 & 0.2 \\ 0.3 & 0.4 & 0.1 & 0.2 \end{pmatrix}$

Determine a, b, c, d from (7) large Cauchy distribution function

$$A = (0.31 \quad 0.28 \quad 0.25 \quad 0.16);$$

Fuzzy transformation order $B = A \odot R$, After further normalization, the conclusion is obtained according to the principle of maximum subordination.

When considering issues such as vandalism, loss, etc.:

$$B = A \odot R = (0.457 \quad 0.212 \quad 0.203 \quad 0.128);$$

When considering human damage, loss, etc.:

$$B = A \odot R = (0.247 \quad 0.260 \quad 0.321 \quad 0.172).$$

From the principle of maximum membership degree, it can be concluded that the effects and management of the company before the occurrence of man-made damage and loss will have a great impact. The impact on the company will also fluctuate the total amount of charging treasures. When the cost increases, measures may be taken to reduce the number of delivery points and the total amount of delivery, and the charging standard may be increased to increase the revenue. People going out to charge will be greatly affected.



Figure 6. Annual electricity consumption as a percentage of total electricity consumption

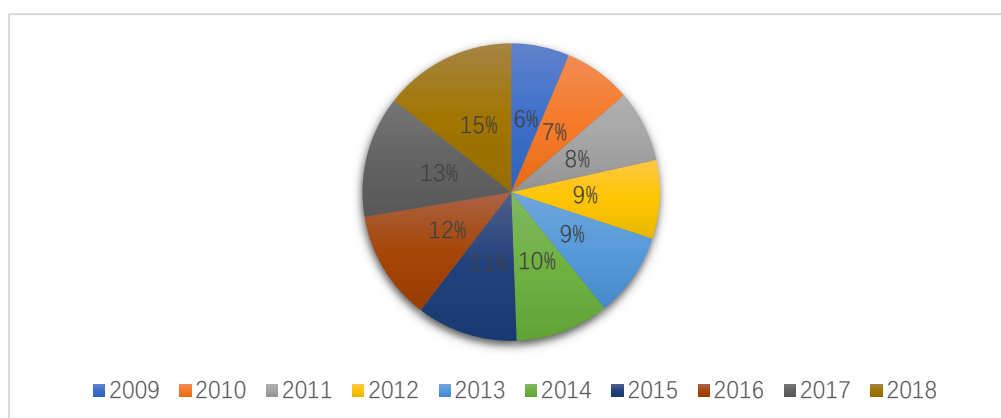


Figure 7. Total electricity consumption

6. Task 3: The Model for Different Types of Public Places

According to the idea of 4, Question 3 asks us to discuss how our model should change for different occasions (such as schools, cafes, coffee shops, airports, shopping centers, etc.). Based on the previous model, we are still only concerned about the energy costs of free charging in public areas.

6.1. The Model for Shopping Malls

In general, the opening hours of the mall are probably from 9:00 am to 10:00 pm, so we can quantify his income and cost function using the following formula.

$$f(t) = \begin{cases} 1 & \text{if } 9 < t < 22 \\ 0 & \text{otherwise} \end{cases}$$

$$Cost = \sum_i c(t_i) P_1 \max(Vr, N) f(t)$$

$$Benifit = \sum_i c(t_i) P_1 \max(Vr, N) f(t) \|t_i\|$$

6.2. The Model for Cafes

We also assume that a cafe opens at 9 a.m. and closes at 10 p.m. A cafe is similar to a shopping mall, except that people in cafes also charge their computers, while people in a shopping mall only charge their mobile phones, so the average power of the equipment in cafes is higher than that in shopping malls. Let P_2 be the average power of computers and cell phones.

In the case of cafes, the model is modified as follows:

$$f(t) = \begin{cases} 1 & \text{if } 9 < t < 23 \\ 0 & \text{otherwise} \end{cases}$$

$$Cost = \sum_i c(t_i) P_1 \max(Vr, N) f(t)$$

$$Benifit = \sum_i c(t_i) P_1 \max(Vr, N) f(t) \|t_i\|$$

6.3. The Model for Universities

Consider a university in China with a building area of 290,000 m², more than 15,000 students and more than 1,200 staffs. According to the survey, the main power-consuming buildings in the school are student apartment, library, office building, teaching building and laboratory building. Figure 9 shows the proportion of the electricity consumption of the school's main buildings in 2017.

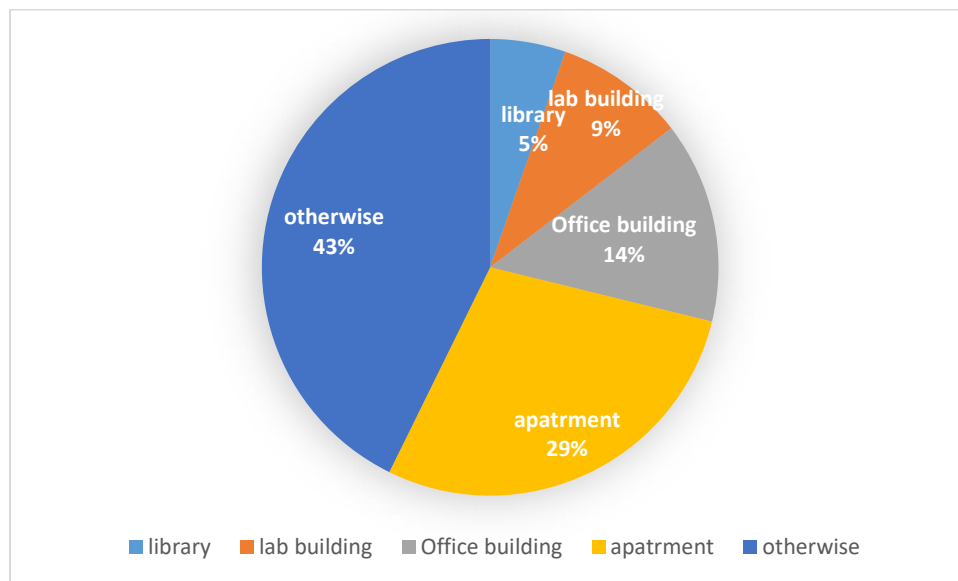


Figure 8. The proportion of the electricity consumption of the school's main buildings in 2017

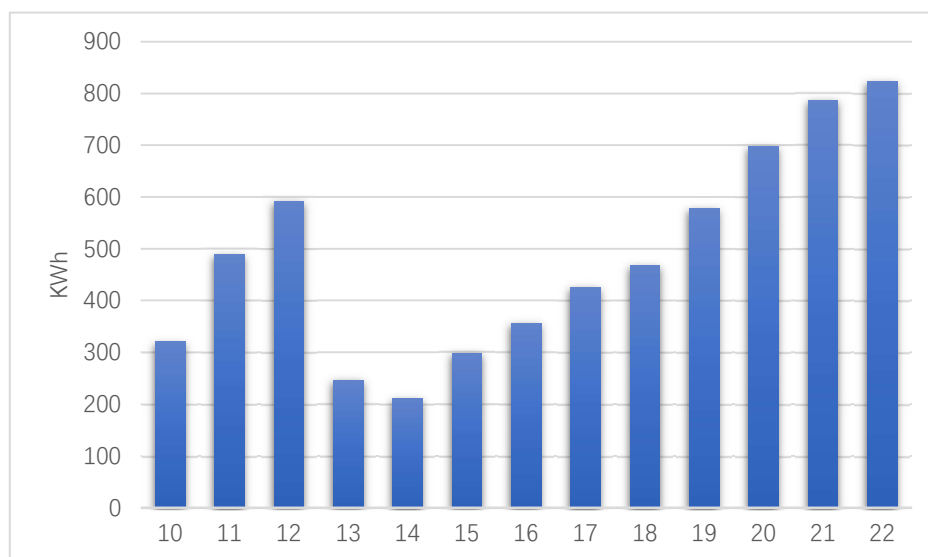


Figure 9. Electricity consumption of office buildings at the university in 2017

7. Task 4: Reduce power cost

7.1. Measures to reduce power cost

There are three measures to reduce power cost.

Government perspective:

Energy-saving work with the nature of public affairs formulate appropriate policies and strengthen the government's own energy-saving demonstration role. To save energy, the government must set an example. The government is a policy maker and should be a positive practitioner of the policy. Government energy conservation can reduce public finance expenditures, and can effectively promote the promotion and application of new energy-saving technologies, new equipment, and new materials through government procurement. More importantly, the government's energy-saving behavior itself is a silent and powerful public relations and mobilization.

Public perspective

Vigorously carry out publicity and education to raise public awareness of energy conservation and mobilize public power.

(1):Energy-saving mobilization should fully reflect the interaction and cooperation between the government and the public, and give full play to the role of civil organizations. Modern society has long ceased to be a society in which the government controls and manages one-dimensionally. For the past, it has never been more like the participation of the public, and it is necessary to truly stimulate the sense of civic responsibility that modern society should have. At this time, the government must establish a more effective and benign cooperative relationship with the public and fully mobilize the public.

(2):Under the goal of energy conservation, the government should meet the daily needs of public places and the public as much as possible, and reasonably arrange the normal working life of the public. At the same time, reduce the loss of profits caused by energy saving in public places in public places. These factors constitute the public's sense of identity with government initiatives.

Public place:

Ensure the implementation of energy conservation in public institutions

(1):According to the comprehensive level and characteristics of energy consumption of public institutions in different industries and different systems, the energy consumption quota shall be formulated. Public institutions shall use energy within the quota of energy consumption and strengthen the management of energy consumption expenditure.

(2):Supervise and urge public institutions to establish and improve the energy conservation management system and energy consumption system operating procedures of the unit, strengthen the operation adjustment, maintenance, inspection and inspection of energy-using systems and equipment, and implement low-cost, no-cost energy-saving measures.

Public building

Promote green buildings and widely use energy-saving materials

(1):Extensive use of renewable resources. Using a variety of renewable energy technologies can greatly reduce the amount of carbon dioxide we produce in the process of using energy. Solar energy can heat water and generate electricity.

(2):Energy-saving decoration in public places. Reduce the amount of aluminum used in decoration. Reduce the amount of steel used. Reduce the amount of wood used for decoration.

(3):Make full use of natural light

8. Report

In recent years, electronic devices have been found everywhere in our lives, and many public places now offer free charging devices that are convenient for people to use. This paper studies the changing rules and future development trends of free charging demand and cost in public places, and gives a concrete model for calculating the cost and demand function of power resources in various occasions.

For the first problem, we first found the use of power resources in the past ten years, and then described the trend of the free charging power demand in public places through a visual method. Then we introduce a time series model to predict the future demand of power resources, and use the data from 2000 to 2018 to predict the trend of power demand in 2019-2025. It can be seen that electricity consumption will continue to increase in the next few years, and the trend is more obvious than before.

Earlier in this article, we modeled the cost of electricity used in shopping malls, cafes, and universities, and estimated the cost. As people's demand for electrical energy increases, the cost of electricity to be paid at each location is increasing. Reducing the cost of using electricity in public places is already imminent. In most public places, there is a serious waste of power resources in the process of using electric energy, and it is necessary to formulate relevant systems to effectively control their energy saving. This paper explains the principle and composition of the energy-saving system in public places, analyzes the hardware and software design of the system, and tests the system functions to understand the system and promote its application. Aiming at the problem that the use of classrooms in colleges and universities and the use of internal electrical equipment are unscientific management, which causes serious waste of energy and other resources, a remote energy-saving control system for teaching

buildings is designed. The system can realize the control and management of the electrical equipment in the teaching building by the user through the mobile phone or the PC, and can automatically control the power supply of the electrical equipment in the classroom according to the school's power-off and power-off arrangements.

Real life can never be explained by scientific statistics alone. Saving electricity and reducing costs cannot be realized by a certain system or measure. As a part of the earth, each of us should save energy and cherish energy. I hope we can Living with a greener and longer-term vision, making a blessing for yourself and your family, and benefiting future generations.

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